Studies on the Gut Contents of a Suctorial Collembolan *Friesea mirabilis* (Tullberg) (Insecta)

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The first important work on the food and feeding habits of Collembola was published by Macnamara (1924). Macnamara discussed the food of Collembola in general and put forward the view that chewing forms, i.e. those with a mandibular molar plate on their mandibles, were vegetarian, and suctorial forms (i.e. without a molar plate on the mandible) were carnivorous. On the examination of the gut content, Macnamara suggested that Collembola were polyphagous, a view which has been shared by many subsequent workers (Agrell 1940, Gisin 1943 and 1948, Kuhnelt 1950, Schaler 1950, Dunger 1956 and 1958). The other workers (Spencer and Stracener 1929, Ingram 1931, Saveley 1939, Brown 1954, and Poole 1959) who studied the food of Collembola, limited their work to chewing forms only. Work on the food and feeding habits of collembolans without a molar plate on their mandible are very few and far between. Imms (1906), Macnamara (1924) and Womersley (1932) are among the few who have casually referred to the food which the suctorial forms feed on. In order to investigate the food of a suctorial Collembola in detail *Friesea mirabilis* was selected. *F. mirabilis* is a very small collembolan (about 0·5 mm. long). It is relatively inactive and without a spring: it has mandibles lacking molar plates. The eyes of *F. mirabilis* are well developed and the animal is lightly pigmented. *F. mirabilis* was found mostly in humus, with a few individuals in the upper and fermentation layers of the soil profile. The distribution observed agrees with those described for the species by Haarlov (1960) and Poole (1961).

Materials and Methods

The food in the alimentary canal of *F. mirabilis* was examined by employing four different methods, i.e. squashes of the gut contents in lactic acid, paraffin wax sections of the gut, smears of the gut contents and the use of cultures to determine the micro-organisms present in the gut. Three different categories of individuals were examined; those with visible gut contents, those without visible gut contents and finally specimens which were starved in the laboratory.

The specimens were collected directly from their habitat and were killed and fixed in the field to avoid further digestion of the food. In the laboratory, fixed specimens were transferred to 20% lactic acid and left overnight at 45°C. Due to the clearing

action of the lactic acid, the gut became visible so that specimens with visible gut contents were easily separated from those without.

Two culture media, Sabouraud agar for fungi and Blood agar for bacteria were used. The external body surface of the insect was sterilised using dilute mercuric chloride solution (see Wilson and Miles 1948, Steinhaus 1946). The insects were washed in sterile water and the gut dissected out. The gut contents were streaked on the culture media with the help of a platinum wire loop.

Examination of gut contents

Examination of the gut contents of *F. mirabilis* showed fluid of a viscous nature which sometimes contained orange coloured collembolan eggs interspersed in it. Occasionally the gut contents were of a very fluid nature.

The squash preparations of the gut of *F. mirabilis* were made in lactic acid. The whole insect was stained, using cotton blue (Aniline blue W.S.) in lactic acid before being examined under a coverslip. The greater bulk of the gut contents were formed of an unrecognisable thick gelatinous matrix-like substance. The individuals with very fluid and colourless gut contents showed some fungal spores, yeasts and minute particles of plant debris, mineral particles, amorphous organic particles and a few protozoa. The suspended particles in the gut contents were either very minute or without any structure, and hence it was not possible to make any quantitative estimate of the materials present. During the summer, a large number of collembolan eggs were found in the gut of *F. mirabilis*. The number of eggs was so great and they were so closely packed that the only likely explanation for their presence in the gut was to assume that the animal had eaten a female collembolan with a mature ovary. Collembola in this condition were common at that time of the year. In addition to the eggs, other tissues of animal origin were present in a macerated state. Out of a total of 53 individuals of *F. mirabilis* examined, 15 had recognisable collembolan eggs in the gut. So far as Protozoa were concerned, only a few encysted amoebae and ciliates were recognised.

Longitudinal and transverse sections were examined and the result agreed with the findings from the lactic acid preparations. The gelatinous matrix in the gut contents observed in lactic acid was seen, in sections, to possess some sort of structure and this stained like the body tissue of the animal (orange and blue in Mallory's and red and blue in Ehrlich's haematoxylin and eosin). The evidence of the collembolan eggs in the gut suggested a carnivorous mode of feeding in *F. mirabilis*. The maximum size of the food particles of animal origin was 0·02 mm. (collembolan eggs). When the gut contained only fluid material with small particles suspended in it, the maximum size of the particles was found to be 0·01 mm. Sections of specimens starved for two

days, showed fluids with only very fine colloidal materials suspended in it. Fungal elements and matrix-like substances were absent. The diameter of the gut was comparatively smaller. Microscopic examinations of the Gram's stained smears of the gut fluid from freshly collected individuals of *F. mirabilis* showed the presence of a large number of bacteria. It was possible to identify gram positive cocci and bacilli and gram negative bacilli. The three types of bacteria were also found in the gut of starved specimens but in smaller numbers.

Examination of the gut contents using Schaudinn's fixative and borax carmine stain, showed only a very few amoebae and ciliates. In order to check the result obtained from Gram's staining and from the examination of squashes of the alimentary canal, the gut contents of freshly collected *F. mirabilis* were cultured on Sabouraud and blood agar media. Examination of eighteen plates showed after four days a large number of fungal and bacterial colonies developing. There were four different types of fungi found, namely *Penicillium, Aspergillus, Thysanoptera* and yeast. They were sub-cultured and a stock was maintained for further studies. Among the bacterial colonies growing on the plates, there were nine gram positive cocci, five gram positive bacilli and twelve gram negative bacilli.

In order to see if viable fungi can pass through the gut of *F. mirabilis,* faeces were cultured on Sabouraud and blood agar media. Freshly collected specimens were externally sterilised with dilute mercuric chloride solution (Steinhaus 1946), washed, and finally left overnight to defaecate on the agar plates. After four days a number of fungal as well as bacterial colonies were found developing. The result showed that viable fungi and bacteria can pass through the gut of *F. mirabilis.* The gut contents of starved specimens when cultured on agar plates showed only bacterial colonies developing.

Discussion

The evidence from the gut contents indicates that *F. mirabilis* feeds on dead and decaying animal tissues which are ingested in a macerated state. During the collembolan breeding season in many specimens the gut was found to be packed with a very large number of orange coloured collembolan eggs embedded in a matrix. This matrix resembled partially digested animal material which stained deep blue in Mallory's triple stain and also in Haematoxylin and eosin. It is very probable that *F. mirabilis* could have ingested the eggs individually because of the very large number of eggs involved. Their being embedded in a matrix suggests that a collembolan with mature ovaries had been eaten. *F. mirabilis* is not the type of animal that could be expected to be an active predator as it is extremely sluggish, weak and minute in size (up to 0·5 mm. long). The evidence suggests that this species is a necrophagous form. Unlike *T. longicornis* and *O.*

ar.natus (unpublished observations), *F. mirabilis* has, therefore, a very different mode of life, quite unconnected with the breakdown of leaf litter.

Bacteria, yeast, and minute fungal spores and hyphae were found in the gut of the majority of specimens. This suggested that yeast and minute fungal materials formed the main diet. Bacteria were also found in the gut of starved specimens and also in the faeces of *F. mirabilis*. This suggests that some of the bacteria might have formed the gut flora while others might have been digested as food. The result obtained from the culture of faecal materials suggested that some viable bacteria, yeast and fungal spores can pass unharmed through the gut of *F. mirabilis*. This helps in propagation of micro-organisms to a new habitat.

Summary

Examination of the gut contents of *Friesea mirabilis* (Tullberg) employing four different methods, revealed that *F. mirabilis* contained tissues of animal origin, unrecognisable matrix and occassionally humus detritus. The fluid gut contents contained bacteria, yeast, fine fungal spores and hyphae. It was shown that viable fungal spores and bacteria could pass unharmed through the gut and thus the insect helps in propagation of micro-organism from one micro-habitat to another.

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